

Guidance on Including ITS Elements in Transportation Projects

**Federal Highway Administration
Office of Travel Management**

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Guidance on Including ITS Elements in Transportation Projects

Purpose

The purpose of this document is to provide guidance for including ITS equipment/technologies as part of traditional transportation construction or maintenance projects.

Scope

This document is not intended to simplify the planning process, rather it is intended to help with a specific part of the planning process.

Intended Audience

The intended audience includes state and local transportation implementers and project developers as well as U.S. DOT field offices. Although planners are not the primary audience, close coordination between planners and transportation engineers is essential to the application of this guidance.

Incorporating ITS into Traditional Transportation Projects

An initial thought may be, “Why would I want to incorporate ITS into traditional transportation projects?” Although the traditional planning process is focused more on capacity expansion and capital improvement projects, ITS implementations across the country have provided many positive benefits such as system efficiency, safety improvements, and time and costs savings. One way for ITS deployments to maintain momentum and financial support is to incorporate ITS infrastructure within the scope of more traditional transportation projects. Incorporating ITS elements into other capital projects just makes good engineering, financial, and political sense. To do otherwise could later entail re-work of previous projects, resulting in lost time and money. More often than not, a lack of coordination in the construction schedules will lead to situations like the digging up of ITS communication cable for a lane widening project or digging up the pavement to lay the cable.

One approach for installing ITS equipment/technologies during traditional transportation projects is to conduct a site-specific ITS assessment. A site-specific ITS assessment is a 3-step process. The assessment can be applied to a particular region, metropolitan planning area, or state, and should be conducted by state or local transportation engineers. The assessment requires some up-front “planning” with transportation staff followed by coordinating with project managers and contractors. Up-front planning for ITS is necessary so that ITS elements can be effectively programmed to be included in other transportation projects

“Part of the I-15 Reconstruction project included the field devices and communications equipment of the ATMS. This helped to avoid conflicts in construction, as \$72 million in ATMS equipment would never have competed well against the \$1.59 billion in highway construction for priority.”

Excerpted from ITS America's Summer 2000 ITS Quarterly question and answer piece with Martin Knopp of the Utah Department of Transportation.

(instead of being added at the last minute or overlooked altogether). Deploying ITS alongside and as an integral part of other transportation projects can result in saving time and money, minimization of re-work, and facilitating modernization and increased benefits such as improved safety and efficiency.

Conducting a Site-specific ITS Assessment

The 3 steps of a site-specific ITS assessment (see figure 1) are described in this section. Working through the steps of the assessment is an iterative process and should *not* be viewed as prescriptive, rather it is intended to provide a basis on which each region or state DOT can build an approach for incorporating ITS infrastructure into traditional transportation projects. Because a site-specific ITS assessment is intended to help with a specific part of the planning process, an overview of the transportation planning process is provided in appendix A. Helpful hints for using this approach are presented at the end of this document.

The **first step** of the site-specific assessment consists of taking an inventory of existing, planned, and future ITS infrastructure. The inventory should be as site- or location-specific as possible. Identify particular corridors, intersections, freeway sections, etc. where ITS elements would improve congestion, safety, and incident management. This initial step should be done independent of any particular project and should be taken across the region or metropolitan area.

In order to complete an effective ITS inventory, preliminary planning for ITS in your region should be completed or at least started. A great place to start is with your organization's input to the most recent metropolitan deployment tracking surveys and regional architecture if they exist for your area. The ITS inventory can be built from the inventory done in conjunction with the regional architecture. Other sources include agency-specific plans, ITS Early Deployment Plans, Statewide ITS Strategic Plans, and state or local DOT inventory lists. From this information you can build an inventory of ITS infrastructure elements that would best meet

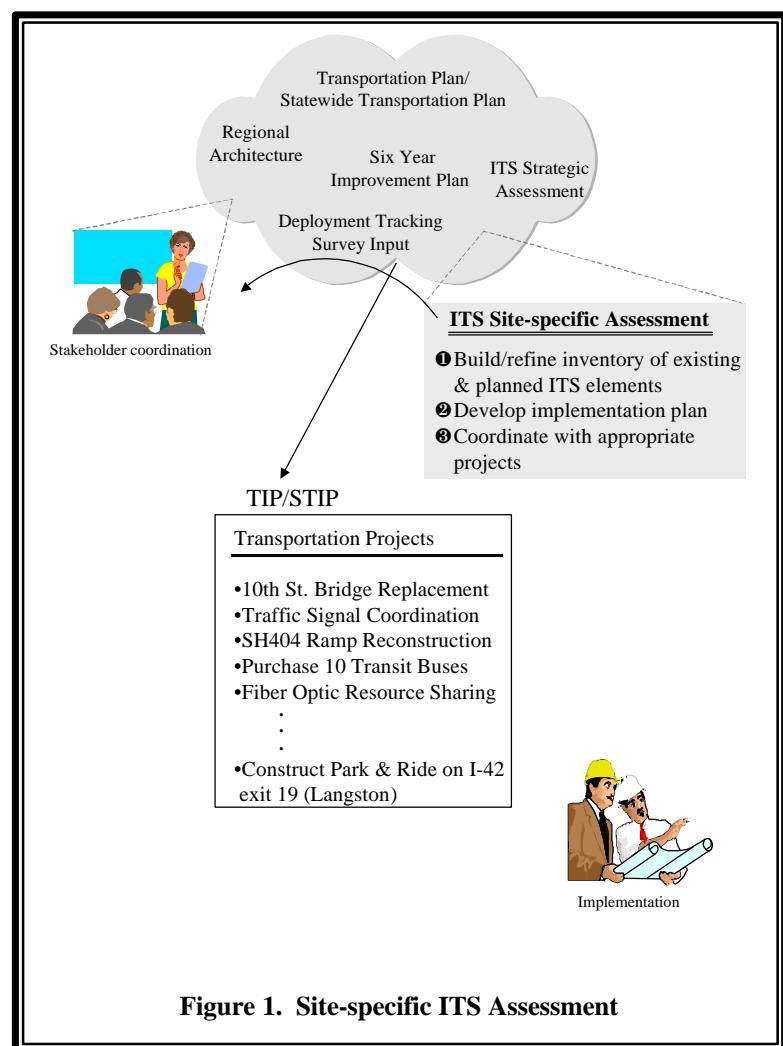


Figure 1. Site-specific ITS Assessment

the transportation issues and problems of your region. In building the ITS inventory keep in mind the functional requirements that need to be met by deploying ITS. Consider the technologies and equipment that are currently available and those available in the near term.

The ITS inventory can serve as a tool to ensure that ITS technology solutions are incorporated into capital improvement plans and that ITS projects are included in the TIP. The sample ITS inventory in figure 2 includes ITS elements that have been either deployed (**existing**), have been identified in the TIP or other plan (**planned**), or are identified as part of the future transportation needs of a region (**future**). This first step is an “up-front” exercise that will prepare your organization to partner with non-ITS projects planned for your region.

Happy Valley Regional ITS Inventory

ITS Inventory Item	Status
Upgraded signals and interconnect for centralized management (from a Transportation Management Center (TMC)) along the Rt.34A and Main Street corridors	Planned
Vehicle detection capability (e.g., radar, video imaging, and loops) along selected I-40 ramps and the Rt.34A and Main Street corridors	Future
Upgraded highway advisory radio (HAR) along major freeways	Existing
Color closed-circuit television (CCTV) cameras for traffic management, vehicle detection, and incident management along major freeways, bridges (15 th Street & Dog River), and corridors	Future
Communication backbone to support ITS technologies along major freeways <ul style="list-style-type: none"> – Fiber optic cable along I-5 between exits 35 and 57 – Lay cable along I-16, I-29, & I-40 in Langston city limits 	Existing Planned
LED variable message signs (VMS) for traffic and incident information dissemination along I-16, I-29, & I-40 in Langston city limits	Future
Electronic toll collection (ETC) for I-16	Future
Traveler information kiosks at I-5 rest areas	Future
Lane control signals for I-16 toll road and major arterials	Future
Trapped vehicle detection and pedestrian gate and warning system at high volume rail/roadway intersections	Future
Automated vehicle location capability on transit buses	Future
Electronic fare payment system on new transit buses	Future
Weigh-in-Motion (WIM) at I-5 weigh stations	Future
Handheld safety inspection devices for commercial vehicle inspections	Existing

Figure 2. Sample ITS Inventory

The **second step** of the site-specific assessment is the development of an implementation plan. This step helps flesh out ITS priorities, needs, budgets, and timing/scheduling. Furthermore, it facilitates “mapping” ITS technologies to related traditional transportation projects. The ITS implementation plan is based on the contents of the ITS inventory. A first step in the implementation plan process is to begin bundling inventory items into candidate improvements, develop timing and phasing schedules, and set priorities and budgets. Each of the inventory

items should be assessed to factor in technologies, location, public/private stakeholders, costs, and priorities (see figure 3). Regional ITS decisions related to system wide or common infrastructure items such as communication backbone, toll tag technology, and NTCIP standards, although not reflected in figure 3, need to be considered and decided on. Information from the implementation plan can be used to coordinate deployment with capital projects. The implementation plan will probably go through several iterations and should be revised over time.

Once ITS equipment items (e.g., variable message signs, color CCTV camera, ramp meters) and quantities are known, a preliminary cost estimate, including capital costs and O&M costs, can be developed. ITS unit cost information is available from the Federal Highway Administration (FHWA) ITS Joint Program Office web site at <http://www.its.dot.gov/eval/itsbenefits.htm>. Other tools and resources available to assist in the development of ITS plans and projects can be found at the end of this document. A copy of the cost information is attached as appendix B.

The **third step** of a site-specific ITS assessment consists of matching up related ITS improvements and traditional projects identified in the Transportation Improvement Plan (TIP) or other planning documents. This includes coordinating any remaining planning, design, development, and deployment of these projects. Consider working ITS projects into private partnership projects such as installing CCTV cameras on cellular towers constructed by telecommunication companies via right-of-way agreements. Such private partnership projects may not be covered in transportation planning documents; however, knowledge of special agreements and projects can be identified through local ITS stakeholders.

Figure 4 highlights possible relationships between sample planned capital projects and sample ITS technologies. The objective is to identify which capital projects present good opportunities to implement items identified through the ITS site-specific assessment process. For example, highway construction and lane-widening projects are usually excellent opportunities to install telecommunication lines or conduits (for later use) to interconnect vehicle detection devices, variable message signs (VMSs), and other roadside ITS devices to a transportation management center (TMC). Likewise, the purchase of new transit buses and light-rail cars provides an opportunity to include ITS technologies such as automatic vehicle location (AVL) devices and other vehicle communication components. Note that the ITS infrastructure elements in figure 4 are not site-specific; however, that information is available in the ITS inventory and ITS implementation plan and does need to be considered when deciding on whether or not there is a good match.

Potential transportation projects identified in the mapping process can be added to the original ITS inventory list (see figure 5). For example, the I-40 lane construction project (063429) could be linked with the inventory entry for planned vehicle detection deployments along I-40. By continuing to add information to the ITS inventory, you can use it as a database for keeping track of your ITS needs and near-term projects. Appendix C contains a generic version of figure 4 demonstrating the connection between traditional capital projects and ITS infrastructure elements.

Happy Valley Regional ITS Implementation Plan		
ITS inventory item	Status	Implementation Factors
Upgraded signals and interconnect for centralized management (from a Transportation Management Center (TMC)) along Rt.34A and Main Street corridors	Planned	Need comm infrastructure. Coordinate w/ vehicle count/detection project
Vehicle detection capability (e.g., radar, video imaging, and loops) along selected I-40 ramps and Rt.34A & Main Street corridors	Future	Radar technology good for I-40. Develop cost estimate for radar & video imaging.
Upgraded highway advisory radio (HAR) along major freeways	Existing	
Color closed-circuit television (CCTV) cameras for traffic management, vehicle detection, and incident management along major freeways, bridges (15 th Street & Dog River), and corridors	Future	Need comm infrastructure. Cost estimate per camera ~\$45K. Investigate mounting on existing structures.
Communication backbone to support ITS technologies along major freeways	Existing Planned	Near term priority. Research possibility of no cost installation in exchange for use of roadway right-of-way.
<ul style="list-style-type: none"> – Fiber optic cable along I-5 between exits 35 and 57 – Lay cable along I-16, I-29, & I-40 in Langston city limits 	Future	Need comm infrastructure. Investigate sign technologies and costs – capital and O&M.
LED variable message signs (VMS) for traffic and incident information dissemination along I-16, I-29, & I-40 in Langston city limits		
Electronic toll collection (ETC) for I-16	Future	Need comm infrastructure.
Traveler information kiosks at I-5 rest areas	Future	Low priority.
Lane control signals for I-16 toll road and major arterials	Future	Need comm infrastructure.
Trapped vehicle detection and pedestrian gate and warning system at high volume rail/roadway intersections	Future	Research incidents at Farmer Rd. and 8 th Street.
Automated vehicle location capability on transit buses	Future	Develop cost estimates for AVL system.
Electronic fare payment system on new transit buses	Future	Develop cost estimates for card readers.
Weigh-in-Motion (WIM) at I-5 weigh stations	Future	Scope installation.
Handheld safety inspection devices for commercial vehicle inspections	Existing	

Figure 3. Sample ITS Implementation Plan

ITS Infrastructure Elements	Planned Capital Projects																			
	Proj No.	15th Street Bridge Construction	Dog River Bridge Rehabilitation	Oak Road Bridge Re-decking	Happy Canal Tunnel Construction	I-40 Lane Construction (Exits 112-134)	I-29 Resurfacing (Exits 40-42)	Widening of King Rd between 1st & 10 Sts	Langston Park and Ride Facility Construction	I-29 Signage & Lighting Improvements Between Exits 45	ITS Computerized Traffic Signal System & Control	Transit Alternative Fuel Vehicles	Route 31A Intersection Signalization Improvements	Canal Point Bike Path Construction	10th St Intersection Improvements	I-29 Interchange Improvements	Main St HOV Enforcement	Main St Signal Light Enforcement	ITS Fiber Optic Resource Sharing	I-16 Corridor Parking Subsidy/Rider Rebate
Fiber Optic Cable or Conduit Install	962110																			
Direct Bury Encased Fiber Cable	963347																			
Loop Detectors Install	908821																			
Video Imaging Detectors Install	95TR32																			
CCTV Camera and Surveillance System Install	063492																			
Variable Message Sign Install	082344																			
Flash Flood Sensor Install																				
Road Weather Information System Install																				
Informational Kiosk Install																				
Transit Status Information Sign Install																				
Emergency Response Software Install																				
Emergency Management Communication System Install																				
Callbox and Motor Assistance System Install																				
Traffic Signal Control Integration																				
Lane Control Integration																				
Automatic Vehicle Location (AVL) Device Install																				
Electronic Fare Payment Integration																				
Weight-in-Motion (WIM) Install																				
Wireline to WIM Facility Install																				
Railroad Lane Gates and Warning Signal Install																				
Potable Traffic Management System																				

Figure 4. Sample Matrix Matching ITS Infrastructure to Related Site-specific Capital Projects (Happy Valley)

Happy Valley Regional ITS Inventory – Revised			
ITS inventory item	Status	Implementation Factors	Projects
Upgraded signals and interconnect for centralized management (from a Transportation Management Center (TMC)) along Rt.34A and Main Street corridors	Planned	Need comm infrastructure. Coordinate w/ vehicle count/detection project	955167 804331
Vehicle detection capability (e.g., radar, video imaging, and loops) along selected I-40 ramps and Rt.34A & Main Street corridors	Future	Radar technology good for I-40. Develop cost estimate for radar & video imaging.	063492 405663 053327
Upgraded highway advisory radio (HAR) along major freeways	Existing		
Color closed-circuit television (CCTV) cameras for traffic management, vehicle detection, and incident management along major freeways, bridges (15 th Street & Dog River), and corridors	Future	Need comm infrastructure. Cost estimate per camera ~\$45K. Investigate mounting on existing structures.	952110 953347 908821 053327
Communication backbone to support ITS technologies along major freeways		Near term priority. Research possibility of no cost installation in exchange for use of roadway right-of-way.	082344 067327 950024 053327
– Fiber optic cable along I-5 between exits 35 and 57			
– Lay cable along I-16, I-29, & I-40 in Langston city limits			
LED variable message signs (VMS) for traffic and incident information dissemination along I-16, I-29, & I-40 in Langston city limits	Future	Need comm infrastructure. Investigate sign technologies and costs – capital and O&M.	803791 95TR61 067327 053327
Electronic toll collection (ETC) for I-16	Future	Need comm infrastructure.	
Traveler information kiosks at I-5 rest areas	Future	Low priority.	
Lane control signals for I-16 toll road and major arterials	Future	Need comm infrastructure.	803924
Trapped vehicle detection and pedestrian gate and warning system at high volume rail/roadway intersections	Future	Research incidents at Farmer Rd. and 8 th Street.	059672
Automated vehicle location capability on transit buses	Future	Develop cost estimates for AVL system.	703211
Electronic fare payment system on new transit buses	Future	Develop cost estimates for card readers.	703211
Weigh-in-Motion (WIM) at I-5 weigh stations	Future	Scope installation.	
Handheld safety inspection devices for commercial vehicle inspections	Existing		

Figure 5. Sample Revised ITS Inventory – Mapped to Capital Projects

There may be instances where there is no opportunity to work ITS projects into traditional highway projects. For example, a region may plan to install toll tag readers and related software to enable electronic toll collection, but there are no construction or maintenance projects planned for the existing toll plazas. In this case, and others similar to it, a separate ITS project must be undertaken. In some cases, it may even be desirable to plan for a separate ITS project (because of the nature and scope of the project, or because of schedule considerations). The ITS fiber optic resource sharing project (053327) listed in figure 4 is one example.

It is good engineering practice to communicate/coordinate with transportation planners and appropriate toll agency members to determine if, during the near term, any road construction or maintenance is likely to be scheduled. Coordination and communication between project owners and planners is critical in order to ensure ITS components are appropriately considered.

It is important to note that **close coordination** between project managers must occur as soon as a traditional transportation project has been identified as a potential match for an ITS project. Note that the mapping of ITS project to non-ITS project is not a one-to-one relationship. More than one non-ITS project could be matched with more than one ITS project, and vice versa. Also, note that the managing/contracting for the ITS elements of a bigger, highway construction project can be done separately as long as coordination occurs. Depending on the projects involved, separate contracts may be put in place, or some type of sub-contract let for the ITS elements. For example, when deploying VMS signs in conjunction with highway construction, the same contractor who will be constructing new lanes might also be under contract to lay the telecommunications conduit, and construct the VMS tower and controller cabinet foundations. An ITS contractor would then be responsible for selecting, purchasing, and integrating the actual VMSs. Regardless of the type of contracting arrangement chosen, coordinating the design, schedules, phasing, and cost control are all aspects that must be considered and worked to ensure that the projects are completed on-time, and with minimal interference.

Additional Resources and Tools:

- **ITS JPO Costs Database** – provides cost data that are useful in developing project cost estimates during the planning process (see appendix B). Cost data and background information are available for download or on-line at <http://www.its.dot.gov/eval/itsbenefits.htm>.
- **ITS Deployment Analysis System (IDAS)** – is a cost/benefit analysis tool for use in the planning of proposed ITS improvements. IDAS (<http://idas.camsys.com>) is available for purchase through McTrans Center at the University of Florida, mctrans@ce.ufl.edu.
- **Turbo Architecture** – assists transportation planners and system integrators in the development of regional and project architectures using the National ITS Architecture as a starting point. Turbo Architecture is available for purchase through McTrans Center at the University of Florida, mctrans@ce.ufl.edu.

- **ITS Mainstreaming at Maricopa County DOT (MCDOT)** – the process used by MCDOT for incorporating ITS into regional planning, design, procurement, and system operations is available at <http://www.aztech.org/its.asp>.

Helpful Hints:

- Communicate and coordinate with planners and project managers within your organization and from other agencies in your region
- Consider ITS solutions as part of TIP projects
- Review deployment tracking survey input from your region
- Determine if an ITS plan or strategy or regional architecture exists at the metropolitan, statewide, corridor, or multi-state level
- Check if the ITS plan is coordinated with the state, other Metropolitan Planning Organizations (MPOs), regional operations, other agencies (e.g., police, fire, incident management)
- Determine if the ITS plan is part of your twenty year Transportation Plan
- Look at Early Deployment Plans (EDPs) as a source for documentation of a regional architecture
- Determine if an ITS inventory has been performed for your area. If not, refer to your area's TIP and transportation plan, or input to the metropolitan surveys (e.g., MPO Survey, Freeway Survey)
- Use figures 2 and 3 as templates as starting points for building your inventory and site-specific ITS assessment
- Review your region's TIP for possible capital projects related to your ITS needs
- Look for opportunities to *piggyback* on capital projects identified in the TIP
- A good time to begin a site-specific ITS assessment is as a follow-on to development of a regional architecture
- Focus initially on ITS improvements needed in the near-to-mid term time frame, but don't overlook your future needs if they dovetail with other projects being implemented in your area
- Match ITS projects with traditional projects in the transportation plan adoption stage
- Talk with project managers about the possibilities of incorporating ITS elements into their capital projects 2-3 years out in order to get the "biggest bang for the buck." Depending upon the project, you may still be able to influence a project that is only 1 year out from implementation
- While going through regional transportation plans and other project/planning documents, identify projects for which ITS should be considered for later discussion with state/local transportation stakeholders (such as potential re-construction projects, or major widening being considered in long range plans)
- Don't forget about ITS during various construction projects
- Bring together the right group of stakeholders in developing an ITS implementation plan (step 2), as this will ensure that opportunities to coordinate with the planned projects of all affected agencies are considered
- Be sure to revisit your ITS implementation plan on a periodic basis to ensure that it maintains relevance and becomes an integral part of the local decision making process
- Develop initial cost estimates for the ITS projects using planning tools such as IDAS or the JPO ITS unit costs database (see Appendix A) as a starting point
- Look for opportunities to make planning for ITS a normal part of the regional planning process

APPENDIX A

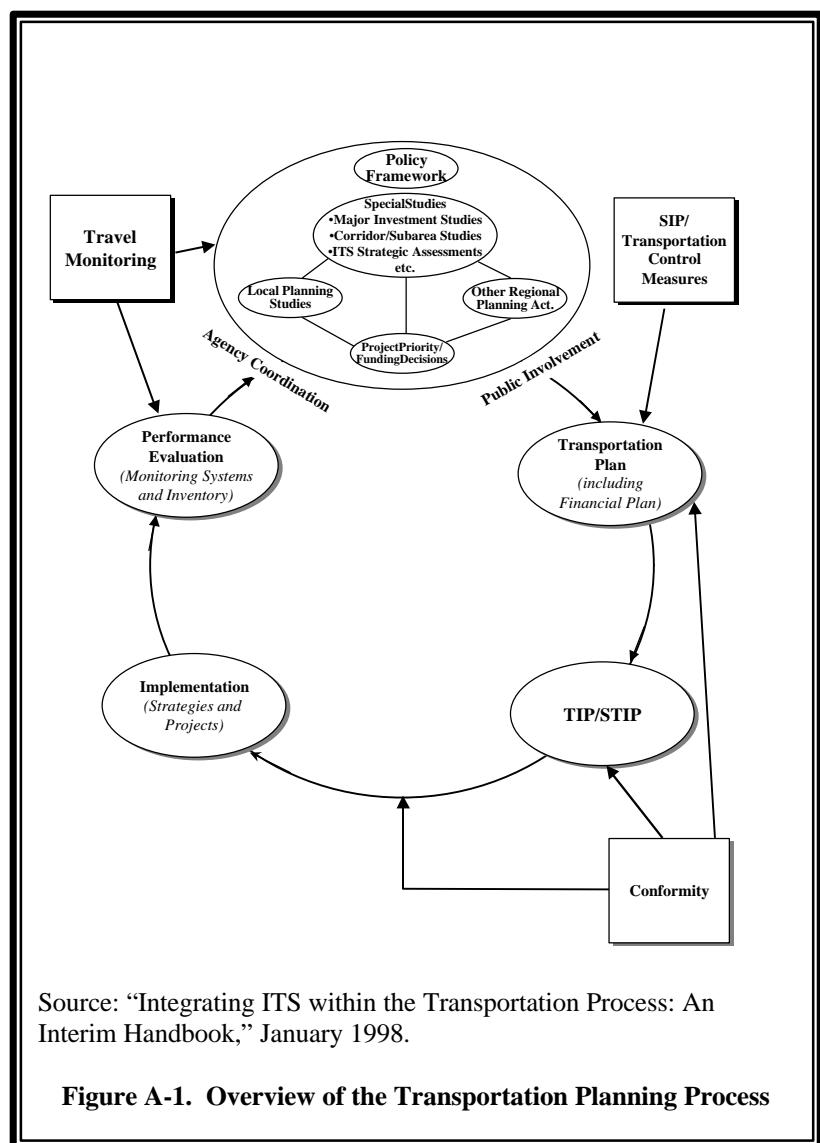
Transportation Planning Process/Project Cycle Overview

Transportation Planning Process/Project Cycle Overview

Although the focus of this document is a site-specific ITS assessment, an overview of the transportation planning process is provided as background information and to set the context for where the site-specific ITS assessment fits into the planning process. Figure 1 shows a sample overview of the transportation planning process. It is important to note that planning for ITS infrastructure deployment should not be a separate process from the regular transportation planning process nor require a change in the transportation planning process itself. Rather, it should be an integral part of the process.

The transportation planning process is an iterative process and has two primary products: the transportation plan and the Transportation Improvement Plan (TIP). Although not part of the planning process, implementation and evaluation are included to reflect the complete project cycle.

The items at the top of figure 1 represent a broad range of transportation planning activities necessary to develop long range transportation plans and identify specific near-term projects. Examples of these activities include establishing goals and policy, identifying project funding/programming, and conducting corridor/subarea studies and ITS strategic assessments. The corridor/subarea studies and ITS strategic assessments are used to consider different transportation strategies, including ITS, as possible solutions to the transportation problems of a geographical area. Products of the ITS strategic assessment include a regional ITS framework and regional architecture which lay out a regional approach or framework for implementing ITS. It is within the context of these planning activities that the ITS site-specific assessment would be conducted.



Each state DOT and metropolitan area are required to periodically prepare a transportation plan and TIP. The transportation plan contains long range transportation plans for a region. The overall policy direction for a region is stated here along with projects and programs to be implemented over a 20-year period. ITS projects and strategies need to be included in the transportation plan. The TIP describes specific projects that will be implemented in the near-term (e.g., 3-5 years). In order to receive federal funding, ITS projects must be included in this plan.

“[An ITS strategic assessment] provides a mechanism for communicating potential ITS initiatives to other parts of the planning process. Other (non-ITS) projects may be able to integrate ITS elements more cost-effectively (e.g., along with a highway construction project) than if the ITS elements were implemented alone.”

Excerpted from “Integrating ITS Within the Transportation Process: An Interim Handbook,” January 1998

For more information on integrating ITS into the transportation planning process, refer to the resources provided below. Many of the documents are available from the Department of Transportation, Federal Highway Administration, ITS Joint Program Office Electronic Document Library (EDL) at <http://www.its.dot.gov/welcome.htm>.

Additional ITS Planning Resources

- “Incorporating ITS into Transportation Planning: Phase I Final Report,” Revised, September 1997 (EDL #7548)
- “Integrating Intelligent Transportation Systems with the Planning Process: An Interim Handbook,” January 1998 (EDL #3903)
- “Transportation Planning and ITS: Putting the Pieces Together,” April 1998 (EDL #3683)
- “Incorporating ITS Solutions into the Metropolitan Transportation Planning Process, Overcoming Institutional Barriers, November 2000 (EDL # 13177)
- “Florida’s ITS Planning Guidelines: Integration of ITS into the Transportation Planning Process,” June 2000 (<http://www.dot.state.fl.us/planning/>)

APPENDIX B

JPO ITS Unit Costs Database

(See website <http://www.its.dot.gov/eval/itsbenefits.htm> for more information about this database)

ITS UNIT COST DATABASE (as of September 30, 2000)

Subsystem/Unit Cost Element	ID#S No. ^a	Lifetime* (years)	Capital Cost (\$K) Low	Capital Cost (\$K) High	O&M Cost (\$K/yr) Low	O&M Cost (\$K/yr) High	Notes
Roadside Telecommunications (RSTC)							
DSI Communication Line	TC001	20	0.5	1	0.6	1.2	5Mbps capacity. Leased with typical distance from terminus to terminus is 8-15 miles, but most of the cost is not distance sensitive.
DSI Communication Line	TC002	20	0.5	1	4.8	8.4	1.54Mbps capacity (T1 line). Leased with typical distance from terminus to terminus is <1 miles, but most of the cost is not distance sensitive.
ISP Service Fee	TC003	20	0.3	24	.72	44.736 Mbps capacity (T3 line). Leased with typical distance from terminus to terminus is 8-15 miles, but most of the cost is not distance sensitive.	
Direct Burly Armor Encased Fiber Cable	TC007			0.12	0.18		Monthly service fee (\$10 to \$15 per month).
Conduit Design and Installation - Corridor					0.02		Cost is per km.
Twisted Pair Installation					0.02		Cost is per km.
Fiber optic Cable Installation					0.02		Cost is per km.
Telephone Drop					0.3		Cost is per drop.
Cellular Communication					0.4		Cost is for one unit.
900 MHz Spread Spectrum Radio					0.4		Cost is per link.
Microwave Communication					0.7		Cost is per link.
Wireless Communications, Low Usage					0.2		125 Kbytes/month available usage.
Wireless Communications, Medium Usage					0.18		0.7 1,000 Kbytes/month available usage.
Wireless Communications, High Usage					0.6		3,000 Kbytes/month available usage.
Roadside Detection (RSD)							
Inductive Loop Surveillance on Corridor					0.5		0.8 Doubleset (4 loops) with controller, power, etc.
Inductive Loop Surveillance at Intersection					1.6		Four legs, 2 lanes approach.
Machine Vision Sensor on Corridor					0.4		One sensor both directions of travel.
Machine Vision Sensor at Intersection					0.4		Four sensors, 4 leg intersection.
Passive Acoustic Sensor on Corridor					0.2		Two sensors both directions of travel.
Passive Acoustic Sensor at Intersection					0.4		Four sensors, 4 leg intersection.
Remote Traffic Microwave Sensor on Corridor					0.2		One sensor both directions of travel.
Remote Traffic Microwave Sensor at Intersection					0.4		Four sensors, 4 leg intersection.
CCTV Video Camera Tower					0.2		Color video cameras. The low end of the range is specific to CCTV for aerial roads.
CCTV Video Camera Tower	RS007	10	10	18	18	30	1
CCTV Video Camera Tower	RS008	20	18	30	30	30	0.9
Flash Flood Sensors					0.6		Per camera location.
Blowing Dust/Visibility Sensors					0.6		Cost is per unit.
Roadside Control (RSC)							
Linked Signal System LAN	RS002	20	40	70	0.4	0.8	Linked signal system LAN
Signal Controller Upgrade for Signal Control	RS003	20	2.5	10	0.2	0.5	Per intersection.
Signal Controller			11	17.5	0.2	0.9	Includes installation of traffic signal controller per intersection.
Traffic Signal			95	115	2.4	3	Includes installation for one signal (four leg intersection). Costs range from traffic signal with inductive loop detection to non-intrusive detection.
Signal Preception Receiver	RS004	5	2	8	0.05	0.2	Two per intersection.
Signal Controller Upgrade for Signal Preception	RS005	10	2	5	0.5		Add-on to base capability (per intersection).
Ramp Meter	RS006	5	30	50	1.5	3.5	Per location. Includes controller, power, etc.
Software for Lane Control	RS011	20	25	50	2.5	5	Software and hardware at site. Software is off-the-shelf technology and unit price does not reflect product development.
Lane Control Gates	RS012	20	100	150	2	3	Per location.
Fixed Lane Signal	RS009	20	6	8	0.6	0.8	Cost per signal.
Roadside Information (RSI)							
Roadside Message Sign	RS010	20	50	75	2.5	3.75	Fixed message board for HOV and HOT lanes.
Wireline to Wireless Message Sign	RS013	20	6	9	0.5	Wireline to CMS (0.5 mile upstation).	
Variable Message Sign - Full Main and Controller	RS015	20	48	120	2.4	6	Includes cost for small and large VMS.
Variable Message Sign Tower	RS016	20	100	25.5	1.2	5	Tower structures for VMS.
Variable Message Sign - Portable	RS014	14	21.5	32	0.6	2	Variable message sign (3-line, 8" character display); includes trailer, solar or diesel powered HAR
Highway Advisory Radio	RS017	20	16	75	1.4	1	Cost of Roadside Weather Information System (RWIS) does not include upgrade to detect blowing dust or flash flood.
Roadside Weather Information System (RWIS)	RS020	5	5	8	0.5	0.8	Radio beacons (per location).
Roadside Rail Crossing (RRC)							
Rail Crossing 4-Quad Gate, Signals	RS021	20	115	130	42.25	4.85	Gates and signals.
Rail Crossing Train Detector	RS022	20	16	21.5	0.77	1.03	Train detector circuitry and communication line from intelligent interface controller (IC) to wayside interface equipment (WE). Assume two track crossing with two 0.5 mile communication lines.
Variable Message Sign - Full Main and Controller	RS015	20	48	120	2.4	6	Includes cost for small and large VMS.
Variable Message Sign Tower	RS016	20	100	25.5	1.2	5	Tower structures for VMS.
Variable Message Sign - Portable	RS014	14	21.5	32	0.6	2	Variable message sign (3-line, 8" character display); includes trailer, solar or diesel powered HAR
Highway Advisory Radio	RS017	20	16	75	1.4	1	Cost of Roadside Weather Information System (RWIS) does not include upgrade to detect blowing dust or flash flood.
Roadside Probe Beacon	RS020	5	5	8	0.5	0.8	Radio beacons (per location).
Rail Crossing Train Detector							
Rail Crossing Controller	TP002	10	5	10	0.5	1	Reader (per lane).
Rail Crossing Pedestrian Warning Signal, Gates	TP003	10	5	10	0.5	1	Cost includes 1 camera/2 lanes.
Rail Crossing Trapped Vehicle Detector	TP004	20	10	15	1.5		Includes COTS software and database.
Toll Plaza (TP)							
Electronic Toll Reader	TP001	10	2	5	0.2	0.5	Mainline structure.
High-Speed Camera	TP002	10	14	21.5	0.2	1.15	Intervention fixed mount camera for security.
Electronic Toll Collection Software	TP003	10	10	15	1	0.1	Per location.
Electronic Toll Collection Structure	TP004	20	5	12.5	0.2	0.5	Includes hardware enclosure installation, modem server, and map software for indoor and outdoor.
Parking Management (PM)							
Tag Readers	RM002	10	2	5	0.2	0.5	Software costs for COTS (low and developed/bought/high).
Tag Upgrade for Interactive Usage	RM003	7	9.55	27.4	0.5	0.8	Interactive information display interface (upgrade from existing interface).
Information Kiosk with Existing Systems	RM004	7	2.2	8	0.5	0.8	Software is COTS.
Kiosk Software Upgrade for Interactive Usage	RM005	5	10	12	1.4	2	A LED display installed at transit terminal that provides status information on transit arrival.
Smart Card Reader Machine	RM006	10	5.5	40	1.85	2	Ticket vending machine for smart card.
Software, Integration for Smart Card Vending	RM007	5	37	5			Software is COTS.
Emergency Response Center (ERC)							
Basic Facilities, Comm for Large Area	EM006	4000	400	400	600	600	For population >750,000.
Basic Facilities, Comm for Medium Area	EM007	3200	3200	400	480	480	For population >50,000 and <250,000.
Basic Facilities, Comm for Small Area	EM008	2800	2800	400	420	420	For population <25,000.

ITS UNIT COST DATABASE (as of September 30, 2000)

Subsystem/Unit Cost Element	IDAS No. ^a	Lifetime* (years)	Capital Cost (\$K)	O&M Cost (\$K/yr)	Notes
			Low	High	
Emergency Response Software					
Emergency Response Labor	EM0001	10	15	30	0.6 Includes 3 workstations.
Emergency Response Software	EM0002	10	70	150	3.5 Includes emergency response plans database, vehicle tracking software, and real traffic coordination.
Emergency Response Labor	EM0003	20	5	50	165 Two people. Salary costs are fully loaded including salary, overtime, overhead, benefits, etc.
Emergency Management Communications Software	EM0004	10	105	180	5 Shared database between 4 sites. Cost is per site. Software is COTS.
Hardware Software Upgrade for E-911 and Mayday 800 MHz, 2-way Radio	EM0005	5		1.7	2.5 Datacommunications translation software, E911 interface software, processor, and 3 workstations.
Emergency Vehicle On-Board (EV)					
Communications Interface	EV0001	10	0.3	2	0.02 Emergency vehicle communications. Cost is per vehicle.
Information Service Provider (ISP)					
Basic Facilities, Comm for Large Area	ISO19	4000	4000	400	600 For population >750,000. (stand-alone)
Basic Facilities, Comm for Medium Area	ISO20	3200	3200	400	480 For population >250,000 and <250,000. (stand-alone)
Basic Facilities, Comm for Small Area	ISO21	2800	2800	400	420 For population <250,000. (stand-alone)
Information Service Provider Hardware	ISO01	5	49.5	0.81	0.99 Includes 3 servers and 2 workstations.
Systems Integration	ISO17	20	90	110	0.99 Integration with other systems.
Information Service Provider Software	ISO02	20	275	550	13.75 Includes database software (COTS) and traffic analysis software.
Map Database Software	ISO03	2	15	30	0.09 Software is COTS.
Information Service Provider Labor	ISO04				250 Cost is per year.
FM Subcarrier Lease	ISO05				120 Cost is per year.
Hardware Upgrade for Interactive Information	ISO06	5	18.9	23.1	0.378 Includes 1 server and 2 workstations.
Software Upgrade for Interactive Information	ISO07	20	250	500	12.5 Trip planning software (includes some development costs).
Added Labor for Interactive Information	ISO08				150 1 Staff @ 50K to 75K. Salary cost are fully loaded prices including base salary, overtime, overhead, benefits, etc.
Software Upgrade for Route Guidance	ISO09	20	250	500	12.5 Route selection software. Software is COTS.
Map Database Upgrade for Route Guidance	ISO10	2	100	200	12.5 Map database software. Software is COTS.
Hardware Upgrade for Emergency Route Planning	ISO11	5	13.5	16.5	0.27 Map database upgrade.
Software Upgrade for Emergency Route Planning	ISO12	20	50	100	2.5 Includes 1 server.
Hardware Upgrade for Dynamic Ridesharing	ISO13	5	5.4	6.6	0.108 Route guidance software. Software is COTS.
Software Upgrade for Dynamic Ridesharing	ISO14	20	100	200	5 Includes 2 workstations.
Added Labor for Dynamic Ridesharing	ISO15	15			10 Software includes some development costs.
Liability Insurance for Dynamic Ridesharing	ISO16				150 1 Staff @ 50K to 75K for 2 shifts. Salary cost are fully loaded prices including base salary, overtime, overhead, benefits, etc.
Software Upgrade for Probe Information Collection	ISO18	20	250	500	50 50K to 100K per year.
Cable TV Traffic Channel Hardware	ISO19	5			25 Software includes COTS and some development cost.
Cable Channel Airtime					Includes hyperconverter, Pentium PC, TV, converter card, video mux, and demux.
Transportation Management Center (TMC)					
Basic Facilities, Comm for Large Area	TM040	4000	4000	400	600 Cost is per year.
Basic Facilities, Comm for Medium Area	TM041	3200	3200	400	480 For population >750,000 and <250,000.
Basic Facilities, Comm for Small Area	TM042	2800	2800	400	420 For population <250,000.
Hardware for Signal Control	TM001	5	15	30	0.132 Includes 2 workstations.
Software, Integration for Signal Control	TM006	5	180	220	5 Software includes some development costs.
Labor for Signal Control	TM002				10 Salary cost are fully loaded prices including base salary, overtime, overhead, benefits, etc.
Hardware, Software for Traffic Surveillance	TM003	20	135	165	6.75 Processor and software.
Integration for Traffic Surveillance	TM032	20	225	275	11.25 Integration with other systems.
Hardware for Freeway Control	TM004	5	15	30	0.27 Software and integration, installation and 1 year maintenance. Software is off-the-shelf technology and unit price does not reflect product development.
Software, Integration for Freeway Control	TM007	5	180	220	225 Includes 2 workstations.
Labor for Freeway Control	TM005				275 Software and integration, installation and 1 year maintenance. Software is off-the-shelf technology and unit price does not reflect product development.
Hardware for Lane Control	TM008	5	5.4	6.6	0.37 Includes 2 workstations and 19" monitor.
Software, Integration for Lane Control	TM009	10	225	275	11.25 Software development and integration and software upgrade for controllers. Software development is fine tune adjustments for local installations. Otherwise, software is COTS.
Labor for Lane Control	TM010				13.75 Labor for 2 operators @ 50% of 100K.
Software, Integration for Regional Control	TM011	10	300	440	90 Software and integration, installation and 1 year maintenance. Software is off-the-shelf technology and unit price does not reflect product development.
Labor for Regional Control	TM012				180 Includes 2 workstations.
Video Monitor, Wall for Incident Detection	TM013	5	40.5	49.5	2.025 Labor for operators 2 @ 50% of 100K and maintenance technician (2 @ 75K). Salary cost are fully loaded prices including base salary, overtime, overhead, benefits, etc.
Hardware for Incident Detection	TM014	5	81.7	119.3	4.085 Includes 1 19" video monitor and 5 video wall monitors (3x3-9 monitors w/switch).
Integration for Incident Detection	TM025	20	90	110	4.5 Includes 1 workstation and 19" monitor.
Software for Incident Detection	TM015	5	90	110	4.5 Integration with other systems.
Labor for Incident Detection	TM016				630 Software is COTS.
Video Monitor, Wall for Incident Response	TM017	5	2.7	3.3	0.135 Includes 1 workstation and 19" monitor.
Hardware for Incident Response	TM018	5	2.7	3.3	0.135 Integration with other systems.
Integration for Incident Response	TM026	20	180	220	0.165 Software is COTS.
Software for Incident Response	TM019	2	13.5	16.5	0.675 Integration with other systems.
Labor for Incident Response	TM020				90 110 Labor for incident management coordinator (1 @ 100K).
Automated Incident Investigation System	TM021	5	5	15	0.25 Includes workstation, input, monopole antenna, Auto Inegration, and AutoCAD software.
Software for Traffic Information Dissemination	TM022	5	10	22	0.5 Includes 1 workstation.
Integration for Traffic Information Dissemination	TM023	20	18	22	0.9 Software is COTS.
Labor for Traffic Information Dissemination	TM024				4.5 Integration with other systems.
Software for Dynamic Electronic Tolls	TM027	5	22.5	27.5	1.125 Labor for 1 operator @ 100K.
Integration for Dynamic Electronic Tolls	TM028	20	90	110	4.5 Includes software installation and 1 year maintenance. Software is COTS.
Software for Probe Information Collection	TM033	3	5	10	0.5 Integration with other systems.
Integration for Probe Information Collection	TM034	5	18	22	1.8 Includes software installation and 1 year maintenance. Software is COTS.
Labor for Probe Information Collection	TM035	20	135	165	13.5 Integration with other systems.
Software for Rail Crossing Monitor	TM036	5	18	22	4.5 Labor for 1 operator @ 4 hours per day @ 100K/year.
Integration for Rail Crossing Monitor	TM037	20	90	110	4.5 Includes software installation and 1 year maintenance. Software is COTS.
Labor for Rail Crossing Monitor	TM038				1.8 Integration with other systems.
Transit Management Center (TR)					
Basic Facilities, Comm for Large Area	TR014	4000	4000	400	600 Operators (1 @ 50% of 100K).
Basic Facilities, Comm for Medium Area	TR015	3200	3200	400	480 For population >750,000 and <250,000.

ITS UNIT COST DATABASE (as of September 30, 2000)

Subsystem/Unit Cost Element	IDAS No. ^a	Lifetime* (years)	Capital Cost (\$K)	O&M Cost (\$K/yr)	Notes
			Low	High	
Basic Facilities/Cost for Small Area					
Transit Center/Hardware	TR016	10	2800	400	420
Transit Center Software, Integration	TR001	20	8.15	1720	6
Transit Center Additional Building Space	TR003			6	12
Transit Center Labor	TR004	20	20	40	9
Upgrade for Auto. Scheduling, Run Cutting, or Fare Payment	TR005	20	225	500	250
Integration for Auto. Scheduling, Run Cutting, or Fare Payment	TR012	20	40	60	0.8
Further Software Upgrade for E-Fare Payment	TR013	20	10	15	1.2
Vehicle Location Interface	TR007	20	27.5	0.75	16.5
Vehicle Location Equipment	TR008	10	15	20	1
Video Monitors for Security System	TR009	10	55	90	1.8
Integration of Security System with Existing Systems	TR010	20	250	500	247
Labor for Security System	TR011			202	
Toll Administration (TA)					
Toll Administration Hardware	TA001	5	10	15	1
Toll Administration Software	TA002	10	40	80	4
Toll Vehicle On-Board (TV)					
Driver Interface and Schedule Processor	TV001	10	0.3	0.5	0.006
Cell Based Communication Equipment	TV002	10	0.15	0.25	0.0075
GPS/DGPS for Vehicle Location	TV003	10	0.5	0.8	0.01
Signal Precognition Processor	TV004	10	0.3	0.6	0.006
Trip Computer and Processor	TV005	10	0.1	0.15	0.002
Security Package	TV006	10	4.2	5.3	0.21
Electronic Fender Box	TV007	10	0.8	1.5	0.04
Commercial Vehicle Administration (CA)					
Commercial Vehicle Admin Hardware	CA001	10	15	30	0.3
Commercial Vehicle Admin Software, Integration	CA002	20	200	220	4
Commercial Vehicle Admin Labor	CA003	20	5	10	0.25
Software Upgrade for Electronic Credential Purchasing, Mgt	CA004	20	60	140	1.2
Software Upgrade for Inter-Agency Info Exchange	CA005	20	20	40	0.4
Added Labor for Inter-Agency Info Exchange	CA006	20	14	21	0.7
Software Upgrade for Safety Administration	CA007	20	40	80	0.8
Commercial Vehicle Check Station (CC)					
Check Station Structure	CC001	20	50	75	0.6
Signal Board	CC002	10	10	15	1
Signal Indicator	CC003	20	5	10	0.25
Wireline to Roadside Beacon	CC004	10	5	8	0.5
Check Station Software, Integration	CC005	20	10	20	0.8
Check Station Hardware	CC006	20	180	215	0.8
Detection System	CC007	10	0.3	0.5	0.006
Software Upgrade for Safety Inspection	CC008	10	50	75	0.006
Handheld Safety Devices	CC009	20	40	80	0.8
Software Upgrade for Citation and Accident Recording	CC010	5	3	5	0.3
Software Upgrade for Citation and Accident Recording	CC011	20	20	40	1
Weight-In-Motion Facility	CC012	10	14	21	1.4
Wireline to Weight-In-Motion Facility	CC013	10	1	2	0.1
Commercial Vehicle On-Board (CV)					
Electronic ID Tag	CV001	10	0.65	1.1	0.013
Communication Equipment	CV002	10	1.15	2.25	0.017
Central Processor and Storage	CV003	10	0.3	0.5	0.006
GPS/DGPS	CV004	10	1.1	2.2	0.04
Driver and Vehicle Safety Sensors, Software	CV005	10	0.17	0.35	0.017
Cargo Monitoring Sensors and Gauges	CV006	10	20	40	0.4
Fleet Management Center (FM)					
Fleet Center Hardware	FM001	10	15	30	0.3
Fleet Center Software, Integration	FM002	20	215	500	0.6
Fleet Center Labor	FM003	20	80	180	337
Software for Electronic Credentialing, Clearance	FM004	20	40	100	4
Software for Tracking and Scheduling	FM005	20	10	15	10
Vehicle Location Interface	FM006	20	20	40	0.4
Software Upgrade for Fleet Maintenance	FM007	20	100	200	2
Integration for Fleet Maintenance	FM008	20	20	40	0.4
Software Upgrade for HAZMAT Management	FM009	20	5	10	0.1
Hazardous Waste Management	FM010	10	0.15	0.3	0.003
Vehicle On-Board (VS)					
Communication Equipment	VS001	7	0.2	0.4	0.004
In-Vehicle Display	VS002	7	0.05	0.1	0.001
In-Vehicle Signing System	VS003	7	0.16	0.4	0.002
GPS/DGPS	VS004	7	0.25	0.5	0.005
GIS Software	VS005	7	0.1	0.15	0.002
Route Guidance Processor	VS006	7	0.8	1.1	0.016
Vehicle Location Interface	VS007	7	0.04	0.1	0.008
Electronic Toll Equipment	VS008	7	0.15	0.65	0.003
Mayday Sensor and Processor	VS009	7	0.5	0.5	0.006
Sensors for Longitudinal Control	VS010	7	0.5	0.6	0.01
Advanced Steering Control	VS011	7	0.15	0.3	0.006
Advanced Cruise Control	VS012	7	0.15	0.3	0.006

ITS UNIT COST DATABASE (as of September 30, 2000)

Subsystem/Unit Cost Element	IDAS No. ^a	Lifetime* (years)	Capital Cost (\$K)		O&M Cost (\$K/yr)		Notes
			Low	High	Low	High	
Intersection Collision Avoidance Processor, Software	V\$013	7	0.28	0.55	0.0056	0.011	Software processor for infrastructure transmitted information, interface to in-vehicle signing and audio system, software and processor to link to longitudinal and lateral vehicle control modules based on input signal from vehicle intersection collision warning equipment package. Software is COTS.
Vision Enhancement System	V\$014	7	1.2	2.2	0.06	0.11	In-vehicle camera, software & processor, heads-up display, and infra-red sensors (focal sensor system). Software is COTS.
Driver and Vehicle Safety Monitoring System	V\$015	7	0.66	1.25	0.033	0.0625	Safety collection processor and software, driver condition sensors, six vehicle condition sensors @ \$50 each, and vehicle data storage. Software is COTS.
Pre-Crash Safety System	V\$016	7	1.1	2.15	0.037	0.067	Vehicle condition sensors, vehicle performance sensors, software/processor, interface, pre-crash safety systems deployment actuators. Software is COTS.
Software, Processor for Probe Vehicle	V\$020	7	0.05	0.15	0.001	0.003	Software and processor for communication to roadside infrastructure, signal generator, message generator. Software is COTS.
Active Tag		7	0.02	0.05	0.002	0.005	Read-only vehicle tag.
Passive Tag		5	0.05	0.05			Vehicle tag that can be updated (writable).
In-Vehicle Navigation System		7		2.8			COTS product that includes in-vehicle display and supporting software.
Personal Devices (PD)							
Basic PDA	PD001	7	0.25	0.4	0.005	0.008	Personal digital assistant.
Advanced PDA, for Route Guidance, Interactive Information	PD002	7	0.5	0.75	0.01	0.015	Personal digital assistant with advanced capabilities (route guidance, interactive).
Modem Interface, Antenna for PDA	PD003	7	0.18	0.25	0.0036	0.005	Modem interface and separate antenna for wireless capability.
PDA with Wireless Modem		5		1.33			Personal digital assistant with wireless modem.
Software Upgrade for Interactive Information		7	0.1	0.2	0.002	0.004	Software is COTS.
GPS /DGPS	PD005	7	0.5	0.8	0.025	0.04	GPS/DGPS.
GIS Software	PD006	7	0.1	0.15	0.005	0.0075	Additional GIS/GUI capability.

^a Applicable only to unit cost elements used in IDAS

* Not available for several equipment or subsystems

COTS - Commercial off-the-shelf

APPENDIX C

Generic Sample Matrix Mapping ITS Infrastructure to Related Traditional Capital Projects

Figure C-1. Sample Matrix Matching ITS Infrastructure to Related Traditional Capital Projects